CHAPTER 1
INTRODUCTION

1-1. Purpose and scope.

This manual contains guidance for preparing plans and specifications and for ensuring the quality of recycled bituminous and portland cement concrete. In addition, this manual provides useful information to design engineers, laboratory personnel, and inspectors concerning the mix design, plant production, and laydown of recycled pavement mixtures. The emphasis is on airfield pavements; however, the concepts also apply to other pavements.

1-2. References.

Appendix A contains a list of references used in this document.

1-3. Recycling pavement development.

Recycling pavement materials has proved to be a feasible process to rehabilitate worn-out pavements. Since recycled pavements will not always be cost-effective, recycling should be considered when repairing or rehabilitating existing pavements. The use of recycled materials in pavement maintenance and rehabilitation has increased for the following reasons:

a. Environment. Prior to the inception of recycling techniques, the reconstruction of old pavements often consisted of removing, stockpiling, or disposing of old pavement materials. Recycling of these pavement materials uses an inexpensive, available material and eliminates the disposal problem.

b. Material cost. In the last several decades the public and Government have recognized that there is not an unlimited supply of natural materials. The amount of asphalt and high-quality aggregate available for construction is limited. This fact, along with an inflated economy, has caused a substantial increase in the cost of pavement materials and thus encouraged the use of recycle materials. The rising cost of fuel and equipment required to haul the asphalt and aggregate to job sites has encouraged recycling, especially as the haul distances become longer.

c. Technology and equipment. The increased interest in recycling pavements has brought about the development of technology and equipment for recycling that results in an overall reduction in cost when recycled materials are used. There still exist problems that are peculiar to recycling; however, the number and the complexity of these problems have been reduced significantly in recent years.

1-4. Bituminous pavement recycling.

Bituminous pavement recycling methods can be divided into the following three categories: surface recycling, cold-mix recycling, and hot-mix recycling. Table 1-1 lists the advantages and disadvantages of the various methods. Many types of distresses can be corrected by one of the three pavement recycling methods identified in figure 1-1.

a. Surface recycling. Surface recycling, heater-planing-scarifying, cold milling, and rejuvenating are methods of surface recycling that are used to increase skid resistance, decrease permeability to air and water, and improve properties of the asphalt binder. Depending on the process used, surface recycling may modify the top ¼ to ½ inch of pavement. However, surface recycling does not increase the strength of the pavement. The cost to scarify and rejuvenate pavement is approximately the same as the cost of an additional 1 inch of overlay, but the benefits of the additional 1 inch of overlay usually exceed the benefits obtained from the scarification and rejuvenation.

b. Cold-mix recycling. Cold-mix recycling is a process which reclaims most or all of the existing bituminous pavement by breaking it to a maximum particle size of 1 to 1½ inches, mixing it with virgin materials, if needed, and reusing the mixture as a pavement material. Cold recycling material can be used to surface secondary roads, if a seal coat is applied, and as a base course for high-quality pavements.

c. Hot-mix recycling. Hot-mix recycling is a process which involves removing the existing asphalt concrete, crushing it if necessary, and mixing it in a hot-mix plant with new aggregate, asphalt, and recycling agent, when required. The hot-mix recycled asphalt concrete can be designed for use in all types of pavements. Crushed portland cement concrete has also been used as aggregate for hot recycled mixtures.

1-5. Portland cement concrete recycling.

Portland cement concrete recycling involves reclaiming existing portland cement concrete pavements and structures by crushing them to produce construction aggregate for reuse. Table 1-1 lists the advantages and disadvan-

Table 1-1. Advantages and disadvantages of bituminous and portland cement concrete pavement recycling

Pavement Recycling Method	Advantages	Disadvantages
1. Surface recycling		
Heater-remix-overlay	1. Minimizes traffic disruption 2. Requires less new materials 3. Retards reflective cracking with thin overlay 4. Smooths out minor roughness	1. Tendency to violate pollution standards 2. Difficult to control quality of overlay mix 3. Should be used only on structurally sound pavements 4. Burning of old asphalt may occur 5. Quality control on job is difficult to obtain
Cold milling	1. Improves rideability of pavement 2. Can be used with asphalt concrete and portland cement concrete pavements 3. Improves skid resistance of overlay 4. Provides a good temporary solution if money is not available for complete overlay 5. Reduces thickness of overlay required 6. Minimizes traffic disruption	1. Possible foreign object damage problem 2. Should be used only on structurally sound pavements
Rejuvenator	1. Minimizes traffic disruption 2. Quick and easy to apply 3. Least expensive	1. Temporarily reduces skid resistance 2. Should be used only on structurally sound pavements 3. Cannot be used on pavement with rich asphalt content
2. Cold-mix recycling	1. Uses old pavement 2. Prevents reflective cracking 3. Improves structural soundness of pavement 4. Improves frost susceptibility 5. Allows for subgrade repairs if necessary	1. Traffic disruption 2. Requires an overlay 3. May not be cost-effective
3. Hot-mix recycling	1. Uses old pavement 2. Requires less new materials 3. As good as new pavement 4. Maintains present drainage patterns and structures 5. Prevents reflective cracking 6. Allows for subgrade repairs if necessary	1. Traffic disruption 2. May not be cost-effective
4. Portland cement concrete recycling	1. Uses old pavement, eliminating disposal problems 2. A good source of aggregate for either asphalt concrete or portland cement concrete pavements 3. Allows for subgrade repairs if necessary 4. Can be used as cement-treated base or an aggregate base	1. Traffic disruption 2. Angularity of fines may require addition of natural sands to improve workability 3. If concrete contains steel reinforcement, the removal of this reinforcement is necessary

Pavement Distress[a]	Severity Level[b]	Surface Recycling			Cold-Mix Recycling	Hot-Mix Recycling	SEAL Cracks	Remove and Replace	Surface Seal	Overlay
		Rejuvenators	Heater-Planer-Scarifier	Cold-Milling						
Alligator or Fatigue Cracking	L	X					X		X	
	M		X			X				X
	H				X	X		X		X
Bleeding			X	X		X				X
Block Cracking	L	X					X		X	
	M		X			X	X	X		X
	H					X		X		X
Corrugation	L									
	M				X	X		X		X
	H				X	X		X		X
Depression	L		X					X		
	M		X		X	X		X		X
	H				X	X		X		X
Jet Blast Erosion									X	X
Joint Reflection Cracking from PCC (Longitudinal and Transverse)	L						X			
	M						X			
	H					X	X			X
Longitudinal and Transverse Cracking (Non-PCC Joint Reflective)	L	X							X	
	M	X					X		X	
	H				X	X	X	X		X
Oil Spillage				X						
Patching and Utility Cut Patch	L									
	M			X					X	
	H							X		
Polished Aggregate			X	X						X
Raveling and Weathering	L	X							X	
	M	X	X						X	X
	H					X				X
Rutting	L									
	M		X			X				X
	H					X				X
Shoving of Asphalt Pavement by PCC Slabs	L									
	M			X						
	H							X		
Slippage Cracking						X		X		
Swell	L									
	M			X						
	H							X		

a Detail description given in Air Force Regulation AFR 93-5, "Airfield Pavement Evaluation Programs," 18 May 1981.
b L = Low, M = Medium, H = High, refer to AFR 93-5 for description.

Figure 1-1. Method of repair guide for bituminous pavement rehabilitation.

tages of portland cement concrete recycling. The construction aggregate can be used for portland cement concrete pavements, Econocrete, cement-treated base, and aggregate base. Figure 1-2 presents types of distress that may be corrected by portland cement concrete recycling. Other repair methods are shown for comparison purposes.

Pavement Distress[a]	Severity Level[b]	Remove and Replace With PCC	Remove and Replace With New PCC	Overlay	Seal Cracks	Slab Jacking	Cold Milling
Blow Up	L	X	X				
	M	X	X				
	H	X	X	X			
Corner Break	L				X		
	M				X	X	
	H	X	X	X		X	
Longitudinal, Transverse, and Diagonal Cracks	L				X		
	M				X		
	H	X	X	X	X		
Durability ("D") Cracking	L				X		
	M	X	X	X			
	H	X	X	X			
Joint Seal Damage	L				X		
	M				X		
	H				X		
Patching, Small (Less than 5 S.F.)	L						
	M		X				
	H		X				
Patching, Large (Over 5 S.F.) and Utility Cut	L						
	M		X	X	X		X
	H		X	X			
Popouts		X	X	X			
Pumping					X	X	
Scaling, Map Cracking, and Crazing	L						
	M	X	X				
	H	X	X				
Settlement or Faulting	L						X
	M					X	X
	H	X	X			X	X
Shattered Slab/Intersecting Cracks	L						
	M	X	X	X			
	H	X	X	X			
Shrinkage Cracks					X		
Spalling (Transverse & Longitudinal Joint)	L						
	M		X				
	H	X	X	X			
Spalling (Corner)	L				X		
	M	X	X				
	H	X	X				

a Detail description given in Air Force Regulation AFR 93-5, "Airfield Pavement Evaluation Programs," 18 May 1981.
b L = Low, M = Medium, H = High.

Figure 1-2. Method of repair guide for portland cement concrete rehabilitation.